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PHILOSOPHICAL SIGNIFICANCE OF THE "FEEDBACK" CONCEPT
IN CYBERNETICS

-USSR-

by L. S. Petrushenko

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FOREWORD

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PHILOSOPHICAL SIGNIFICANCE OF THE "FEEDBACK" CONCEPT
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Following is the translation of an article by L. A. Petrushenko in Vestnik Leningradskogo Universiteta (Herald of the Leningrad University), No 17, Leningrad 1960, pages 76-86. ⁽³⁾

SCR Ekon, Filosofii i Prava,

Contrary to the philosophical views of the founder of cybernetics, the American scientist N. Wiener [see Note], cybernetics are based on the materialistic concept which maintains that cybernetic systems (living organisms and cybernetic machines) are material and exist objectively, that they exist in a state of interrelationship and interconditionality and that all significant changes in their internal structure and activity result from the conflict of opposite tendencies.

(Note: N. Wiener calls himself an existentialist and is of the opinion that cybernetics make a positive contribution to this philosophy. In incorrectly identifying the vulgar materialism of the XIX century and dialectical materialism, N. Wiener attempts to stand above the materialistic and idealistic points of view. He denies the material nature of information and predicts the destruction of the universe from entropy (thermal death), but in his scientific investigations, in cybernetics, N. Wiener is a naturalistic materialist.)

The theory of cybernetics shows the interrelationship between some of the concepts prevalent in cybernetics, such as "signal," "message," "information," "feedback control," "system," etc., but it does not say anything of the reason why these concepts are interrelated or on what common objective regularities are their relationships based. [See Note].

(Note: The historical approach to the study of the above concepts does not exist in literature. This impedes the visualization of the boundaries within which these ideas are applicable to the natural and technical phenomena.)

This is ascribed to the fact that this problem is the philosophical problem of cybernetics. The existence of such problems in cybernetics explains why the problems of the rationality of the behavior of living organisms and cybernetics machines and the question as to whether a machine is able to think [See Note] or whether information is material, etc., are widely discussed in the contemporary philosophical and, mainly, technical literature of the US, Britain, and France.

(Note: See the discussions in the journals: Philosophy, 1956-1957; and British journal Philosophy of Science, 1956; and also articles in Proc. of the IRE, Electronics, Computers and Automation, 1957-1959.)

During the past decade in the US alone a tremendous number of discussions, conferences, and symposiums on cybernetics and related sciences were held. Almost every conference or symposium includes lectures in which the general problems of cybernetics are examined from the positions of mechanicism and idealism [See Note]. These lectures alone, if collected together, would fill tens of volumes.

(Note: For example, during the conference of the Western Computing Center in the US (3-5 March 1959) the following lectures were delivered: "The Philosophy of and Responsibility for Calculating-Computing Technology in Society," and "Can Cybernetic Machines Solve Social Problems?" The lectures were delivered by professors of Stanford University and the University of Michigan, representatives of firms, etc.)

Nevertheless, our philosophers devote virtually no attention to the wave of "cybernetic fetishism" which has engulfed the mass technological literature of the US and other capitalistic countries, even though a demonstrative and theoretically sound criticism could aid foreign and Soviet technicians and engineers in solving the problems of cybernetics. For example, the science of cybernetics maintains that there is a community (similarity) in the principles of the method of control in living organisms and in machines [See Note].

(Note: Moreover, this idea is considered to be one of the postulates of the origin of cybernetics and an axiom, a point of departure, for further investigation in cybernetics, biology, physiology, and genetics.)

If the above is true, then does not this community (similarity) of two methods of control conceal a still more communal type of regulation, a more common objective regularity inherent not only in living organisms and cybernetic machines but in certain other phenomena as well?

The theory of cybernetics provides sufficient basis for an attempt to distinguish the fundamental concepts (terms) of cybernetics and, from the concept of their interconditionality, to express some general ideas on a broader interpretation of these fundamental concepts and, in particular, on the process of control based on the feedback principle.

If this interpretation does not contradict but, to the contrary, originates from the theory and practice of cybernetics, then it must aid in the investigation of the over-all interrelationship and interconditionality in nature.

Phenomena and processes which exhibit common objective properties and features characteristic of the system of control and communication exist in nature and technology. This enables us to examine from a single point of view even such different phenomena as a living organism and a cybernetic machine. From the point of view of cybernetics they are dynamic systems of control and communication which are characterized by continuous

changes of their method of operation (working conditions), the degree of complexity of their internal structure, and changes (i.e., rise or fall) of the level of their organization and the stability of their existence in relation to the variation of the amount of information accumulated in the system and the changes in the surrounding conditions.

The movement of the information received into the system from without (i.e., the communication of this system through information with the surrounding medium or another system) and the circulation of the information within the system (if the internal structure of the system permits this to happen) is considered by the science of cybernetics to be the principal condition for the very existence of the system.

Thus, all processes and phenomena studied by the science of cybernetics are regarded by it in the state of continuous movement and change /See Note/.

(/Note:/ "From the point of view of cybernetics the world is an organism...a process," writes N. Wiener. However, he interprets these concepts in the spirit of the pessimistic philosophy of S. Kierkegaard and the existentialists. See N. Wiener, Jam Mathematician, New York, 1956, pages 327-328.)

In most instances this movement is controlled (regulated) according to the feedback principle.

The amount of information accumulated by the system as the result of its interactions with other systems or the surrounding medium determines the specific level of the organization and the structure of the given system. In its turn, the specific structure of the communications of the system and, in particular, the existence of a chain along which the feedback signals are transferred, determines such a constant form of character of the movement of information in the system, which under certain conditions permits the system to control its actions (mode of operation) in such a manner as to increase the amount of information accumulated by the system. This method of control is termed feedback control in cybernetics. This method of control is characteristic not only of the cybernetic machines but of living organisms also.

In order to show that such a method of control can exist only in a system of a certain structure, let us examine an abstract instance when there exist at least two channels of communication (Fig 1 a) and they can be connected by the method indicated in Fig 1 b.

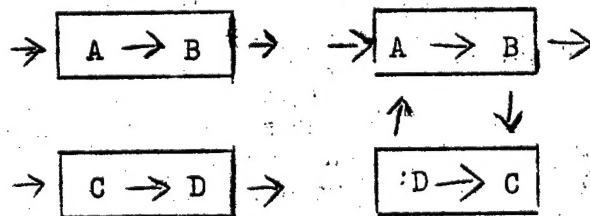


Fig 1. Schematic Portrayal of the Movement of Information
a) in open systems; and b) in a feedback control system.

Under these conditions a number of instances are possible in which the amount of information in the system will not change directly from external influences on the system but will change from the relationship between the two currents of information within the system itself, namely (See Fig 1 b):

1. "Free" information (A-B), i.e., that which passes through the system.
2. "Fixed" information (A-B-C-D-A), i.e., that which circulates in the system.

Among all these possible instances there inevitably exists an instance during which the information (A-B-C-D-A) through the feedback channel C-D [See Note] acts on information (A-B) at the entrance of the system in such a manner that the total amount of information in the system suffers no losses (does not decrease), but acquires an opportunity to accumulate (increase).

(Note: The feedback channel (chain) may exhibit a definite physical meaning and then this channel will represent a usual conductor in technology, nerve fibers in physiology, and succession of generations of species in genetics.

(However, the feedback channel may be neither a "channel" nor a "chain" in the direct physical sense of the word. Such is the feedback relationship between the position of the pendulum and its angular velocity, the unaccounted for capacitive or inductive coupling in the design of a radio amplifier, etc.

(The feedback channel in itself neither regulates nor controls anything. The process of regulation [control] in the system is achieved by means of a specific relationship between the streams of information as a result of the difference [contrast] between the assigned and the actual state of the system, which will be explained later.)

Consequently, in a system with such an internal structure a method of control which would contribute to the conservation and increase of the amount of information in the system is actually possible. This creates conditions favorable for raising the level of the organization of the system and its further development.

There probably exist many means of control which would render possible attaining the above result. However, two methods occur most frequently in cybernetic systems: Control (regulation) according to the negative feedback principle, and compensation.

A thermostat can regulate room temperature either on the basis of constant control of the changes of this temperature (feedback control) or by automatically turning on and off the source of heat at specific prescribed time intervals in such a manner as to maintain generally the desired temperature in the room. This method of control is called compensating regulation or compensation. As we see, in contrast to the

feedback principle, compensation is distinguished by the absence of causal connection (in this instance, between the cooling of the room and the turning on of the source of heat).

1. Compensation or compensating regulation is the method of changing or maintaining the state of a certain system by the means used for removing the consequences of interferences, without causal connection between the error in the state of the system and the action of the compensating means.

The same results are attained by means of compensation as by feedback control but compensation is not used in closed system in technology. To the contrary, living organisms frequently combine these two methods of control.

Compensation is used for a "rough" adjustment of the organism to the vitally important conditions of its existence. Feedback control is used for a more precise and fine adjustment of the organism to the surrounding conditions.

However, there is no sharp dividing line between these two methods of control. The inflammatory processes in living tissue and the reflex of blinking can serve as general examples of compensation, but the mechanics of these processes represent feedback control.

2. Negative feedback control is a process which, contrary to the effect of the interfering influences on or interferences with the system, firstly, strives to decrease the difference between the actual and the assigned state of the system and, secondly, acts on the basis of this difference.

This phenomenon was for the first time investigated theoretically in radio engineering in the amplifier theory, where it was used for conservation of stability, the amplification factor, and other qualitative characteristics of the amplifier by means of such a connection which would ensure the supply of a portion of the outgoing voltage back to the entry by means of a feedback device (a transformer, a delay line, etc.).

The process of feedback control in automatic equipment was developed independently of radio engineering. The system of automatic regulation (SAR) is such a closed system of control (for example of a source of energy) in which the output of the system or a certain function of the output is compared with the intake and the difference between the values of the incoming and outgoing signals is used for controlling the basic process of the system in such a manner as to reduce this difference to zero.

An amplifier with a negative feedback and an automatic device are to an equal degree feedback control systems.

In each cybernetic system the process of control by the feedback principle is constructed in the same manner, namely, in such a way that "the information on the results of its own actions be supplied to it as a portion of information in accordance with which it must continue to function" [See Note].

[Note:] N. Wiener, Kibernetika i Obshchestro (Cybernetics and Society), Moscow, Foreign Literature Publishing House, 1958, page 37.)

Consequently, in a feedback control system, an error of action returns into the system in the form of an individual point originating its further action. Thus the deviations (fluctuations) in the action of a system now in one and now in the other direction are corrected in the course of their occurrence without waiting for the moment when they will attain a great value.

In the animal and the vegetable world the sphere of action of the regulation similar to feedback control is so extensive and varied that N. Wiener termed feedback control "the secret of life." A profound internal similarity between the special method of regulation in living nature and in modern technology is evident.

"Sensing the arrival of cold weather the animal hides in its lair, the bird travels southward into warmer lands, the tree halts the development of buds and arrests the unfolding of leaves. Feeling the changes in external conditions the living creature changes its movements, its growth, the various processes of metabolism in a manner most advantageous to itself." This "permits it to adjust to the various constantly changing external conditions, to avoid those that are unfavorable for its life, and to seek the favorable ones." [See Note 7].

([Note 7] P. Yu. Shmidt, Organizm sredi organizmov (Organism Among the Organisms), M.-L., 1941, page 6).

The physiological mechanisms of control and communication of the organism under the conditions of the surrounding medium were originally investigated by such scientists as I. P. Pavlov, I. N. Sechenov, W. B. Cannon [See Note 17]. In 1932 the latter described the phenomenon of homeostasis [See Note 27], consisting of the fact that the sum total of controls maintains the continuity of relationship with the external medium necessary for the organism, as well as the continuity of the relationships within the organism. In this connection such controls frequently act in a sense opposite to the changes in the external medium caused by the action of physical laws. The simplest example of this is the homeothermal state. According to van't-Hoff's law in physical chemistry the lowering of temperature results in slowing down of chemical reactions, which phenomenon is observed in the regular physico-chemical systems and in cold-blooded animals. In warm-blooded animals, however, this brings about the opposite phenomenon, namely, an increase in the rate of metabolism in such a manner that as a result the body temperature is maintained at a constant level of approximately 37°C.

([Note 1:7] In addition to these classical works there were attempts to uncover the general characteristics of the organism as a whole in a plan of purely logical constructions and generalizations. In the 1930's a group of biologists and physiologists followed this course. Therefrom originated the theory of bioergenetism of Rashevskiy, the "system theory" of Bertalanffy and other biological and physiological theories detached from practice and experiments. See L. von Bertalanffy, "An Outline of General System Theory," Brit. I. Philos. Science, No 1, 1950; see also Science, No 111, 1950, page 23, Symp Biophysics, 1953, and others.)

(Note 2:7 W. B. Cannon, The Wisdom of the Body, New York, 1932, p XV, 312.)

This regulation is based on feedback control. Cooling stimulates the activity of special centers located in certain sections of the cerebral cortex (striatum and hypothalamus) which "turn on" the heat-producing mechanism of our body.

Homeostasis is observed not only in macroorganisms but in microorganisms as well. [See Note 7.]

(Note:7 For example, the dissociation phenomenon is characteristic of bacteria which belong to the intestinal group and grow on solid and nutrient media in the form of large and smooth colonies. This phenomenon consists of the fact that when the nutrient medium changes in the unfavorable sense the bacteria begin to separate colonies with a rough surface thereby increasing the resistance of bacteria to certain external action and improving the general position of the bacteria under the conditions of the given medium.)

N. Wiener indicates the similarity between homeostasis and the process of feedback control. He writes of homeostasis as of regulating mechanisms "which manifest a tendency to resist any unfavorable change in their relationship...and represent negative feedback mechanisms of the type which is sometimes embodied in mechanical automations" [See Note 7.]

(Note:7 N. Wiener, Kibernetika i obshchestvo, page 104).

Certain cybernetics, physiologists, biologists, and geneticists including N. Wiener (US), A. R. Ashby (Britain), I. I. Shal'gausen, and A. L. Takhtadzhyan (USSR) assert that the process of natural selection may be regarded as feedback control.

From the theory of cybernetics we know that the number and complexity of the feedback connections of a system increase proportionally to the level of organization and complexity of the feedback control system. Therefore, if the human organism is, in a certain respect, a feedback control system (and this is actually true), then owing to the highest level of the organization and complexity of the human being, it must represent the most complex and diversified system of feedback controls [See Note 7.]

(Note:7 Dzh. Neyman (see symposium Avtomaty (Automatons) Moscow, For. Lit. Pub. House, 1956, page 129) maintains that the living organism is 10^6 times more complex than any known mechanism.

Defensive reactions of the organism caused by the action of the external medium may be the result of regulation based on the feedback principle; however, not every response reaction of the organism may necessarily result therefrom [See Note 7.]

(Note:7 The usual defensive, or "compensating," reaction of the organism 1) represents an individual, more or less random and single action; 2) in most instances does not take into consideration the duration, intensity, specific character of the action, and its danger to the organization of the system; 3) does not exhibit a cyclic and autonomous character; 4) usually does not have a permanent physiological organization

of its own; and 5) is seldom critically important to the vital activity of the organism.)

In 1939 the Soviet physiologist P. K. Anokhin in investigating the rationality of the response reaction of the organism pointed to "The universal regularity in the life of all organisms which directs every reflex activity under any circumstances of the natural existence of animals."

"We have termed this regularity reverse afferentation and ascribed to it a corrective and fortifying action" [See Note].

[Note:] P. K. Anokhin, "Specific Features of the Afferent Apparatus of the Conditioned Reflex and Their Significance in Psychology," Voprosy Psikhologii (Problems of Psychology), No 6, 1955, page 22 [italicized by L. P.]

"The meaning of the term 'reverse afferentation'," writes P. K. Anokhin, lies in the fact that "the afferent signalization produced as the result of reflective action is directed toward that particular complex of processes of the central nervous system which caused the given action on the periphery. This is a 'reverse' afferentation in the true sense of the word, inasmuch as it follows the direction opposite to the completed effector stimulation and arrives at the initial stations which send these stimulations. This process can be schematically depicted in the following manner" (Fig 2) [See Note].

[Note:] Thus, for example, the act of picking up a fork or knife is immediately concluded by a combination of tactile, temperature, visual, and kinesthetic afferent impulses, signaling the termination and success of the given reflex action (Voprosy Psikhologii, 1955, No 6, pages 11 and 23.)

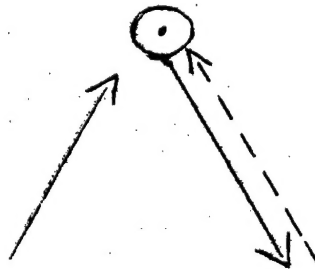


Fig. 2. Schematic Portrayal of the Action of Reverse Afferentation (according to Anokhin)

P. K. Anokhin states that in recent years science abroad is approaching the idea of reverse afferentation, "frequently using even similar expressions." In conclusion the author writes: "This problem is especially closely approached by cybernetics which use the feedback concept for regulating the correctness and rationality of the operations of machines and of the human organism" [See Note].

[Note:] Voprosy Psikhologii, No 6, 1955, page 25)

Not only the physiological, but also the social-productive working activity of man can be regarded as a series of processes performed on the basis of control operating on this principle.

In fact, man in the process of physical work with tools (production) by his activity "regulates and controls the exchange of matter between himself and nature...By affecting external nature with this activity and by changing it he at the same time changes his own nature" [See Note 7].

([Note 7] K. Marx, Kapital, Vol I, Gospolitizdat, 1950, page 184).

However, can the social-productive labor of man be performed without participation of thought and speech? Mental work is another aspect not only of productive but of any other human activity. Still, information which is the basis of feedback control is the "fundamental material of thinking and lies at the base of every mental activity" [See Note 7].

([Note 7] S. Gol'dman, Teoriya Informatsii (Theory of Information), Moscow, For. Lit. Pub. House, 1957, page 337. N. Wiener regards information as the "designation of the contents received from the outer world in the process of our adaptation and the adaptation of all our senses thereto." Kibernetika i Obshchestvo, page 31.)

Our thinking controls, regulates, and supplies the medium for our relationship with the conditions of our existence, with people, with nature.

Consciousness corrects and fortifies the working and perceptual activity of man at the same time being conditioned by it. Consciousness plays a universal defensive role with respect to all functions of the human organism.

In this sense, both the process of work (production) and the process of thinking, consciousness which is expressed and complemented by the process of speech can be regarded as a process of regulation (control) based on the feedback principle.

Thus, in living organisms and in cybernetic machines (and possibly in the vegetable kingdom and in some other phenomena) the movement of information is regulated by the form itself (or by the character) of this movement. In other words, the activity of the cybernetic system is regulated by the results of this activity. This principle of control is termed the feedback principle. Examples show that the feedback control process exists only in the closed system [See Note 1] and is based on the difference between the two states of the system (the prescribed and the actual states), exhibits a cyclic character [See Note 2], is a relatively autonomous process [See Note 3], represents, in essence, a constant form of movement or a constant method of information control in relatively highly-organized and complex systems, and exhibits a structural system of the control process which always remains the same.

([Note 1:] I.e., where the action begins within the system itself, for example, in a thermostat as a result of the difference between the existing and the desired temperature).

([Note 2:] For example, in a feedback controlled thermostat the heat from the source affects the temperature of the room which in its turn affects the action of the source of heat, etc.)

(Note 3:7 "Feedback tends to counteract the action of the system"; "feedback decreases the dependence of the system on the characteristics of the motor"; "the behavior (of feedback control system -- L. P.) is relatively independent of the characteristic and changes in the characteristic of the executive organs used." N. Wiener, Kibernetika, pages 126, 138 and 142.)

If the process of transmission of information is inherent in all dynamic systems of control and communication without exception, the process of feedback control is inherent only in sufficiently highly-organized dynamic systems of control and communication which exhibit a sufficiently complex and developed structure. Being organized in a specific manner these systems can, to a certain degree, change purposefully their own structure by means of feedback control so that the system retains the state favorable for its existence regardless of the effects of the external medium.

The process of feedback control functions on the basis of the difference between the prescribed and actual (or existing) states of the system. For a specific individual or plant the "prescribed state" is characterized by the combination of inherited and acquired during ontogeny properties and features, whereas the "actual state" will, in addition to the above, be caused by the given specific conditions of existence and nutrient medium.

The prescribed state (i.e., the state necessary for the normal course of processes in the system) is directly specified by the internal constitution or structure of the system and the level of its organization, and in the final analysis (from the cybernetic point of view), by the amount of information in the system.

However, since such a system is not isolated and the signal enters together with the distorting interferences which exhibit the character of entropy, therefore, generally speaking, the prescribed state is attained in actual practice only in the ideal instance. Every system while striving to attain the prescribed state, is always in the actual state which the designer or the biologist has to deal with.

The process of feedback control consists of the fact that the appearance of a difference between the prescribed and the actual states of the system is the initial point from which originates a new movement in the system, which is directed along the feedback chain in such a manner that, in spite of the effect of the impeding actions or interferences, it decreases this difference and removes it, inasmuch as this difference (i.e., error in the activity of the system) might be augmented as a result of further activity of the system and might develop to the point where the prescribed and the actual states of the system become opposed which fact may result in the destruction ("desintegration") of the system. Thus the basis of the activity of the system, the changes of its organizational level, the degree of complexity, the process of control (regulation), the process of the variation of the amount of information in the system lie in the unique "conflict of opposite features" which is inherent in all cybernetic systems and determines the self-regulating automatic character of their activity.

A temporary and relative solution of the above indicated conflict in the system occurs when the system (always assisted by the process of feedback control) in some way adjusts to the ambient medium and attains a relative stability which is indispensable for the normal functioning of the system, but this state cannot be preserved indefinitely since the system is not isolated [See Note].

(Note: "Absolute stability is attainable only with extremely large values of entropy and in essence represents thermal death. However, when the system is protected against this thermal death by some conditions governing it, then it will pass a greater part of its existence in the states which are similar to equilibrium, although they are not complete equilibrium. In other words, entropy here is a relative and not an absolute maximum, or at least it changes very slowly in the proximity of these states. It is precisely these states which are similar to equilibrium but are not true equilibrium that are related to life and thinking and all other organic processes." See N. Wiener, Kibernetika, page 209.)

It follows therefrom, in particular, that feedback control is an antientropic agent of the system).

In cybernetics the continuous changes in the difference (opposition) between the prescribed and actual states of the system are merely an external manifestation of a more profound and fundamental opposition between information and entropy in the system, inasmuch as information is the measure of organization and entropy is the measure of disorganization of every system. The opposition between information and entropy, between organization and disorganization, definiteness and indefiniteness of a system may be considered to be the fundamental opposition of a cybernetic system. A change in this opposition is related to the existence of a system in general, independently of the given specific conditions, whereas changes in the difference (opposition) between the prescribed and actual states of the system has a bearing on the existence of the system only under the given specific conditions and it then affects the problem of its adjustment to these conditions.

Because of this, the process of feedback control exhibits, as we know, a cyclic spiraliform character and possibly represents a type of dialectical movement which was defined by V. I. Lenin in Filosofskiye Tetradi (Philosophical Papers) as a "zigzagging movement with a return to the quasi-initial point."

As we can readily see, feedback control is inherent in all sufficiently highly-organized and complex phenomena which exhibit a specific structure.

However, these phenomena, in their turn, historically developed from relatively low-organized and simple phenomena. Consequently, the latter must have a similarly low-organized and primitive control (regulation) as the "prototype" of the feedback control observed in living organisms and machines.

It is a well known fact that the physio-chemical processes historically developed earlier than the biological processes. Consequently, if, for example, natural selection is actually a feedback controlled process then the chemical systems, in spite of their low level of organization, must inevitably have regulating mechanisms of a unique "chemical homeostasis" (inasmuch as the process of natural selection could not have originated in empty space, from nothing).

It is a fact that, notwithstanding the relatively low level of the organization and complexity of the reversible chemical processes (for example, in a gaseous mixture, in liquid, etc.), they can be regarded as dynamic systems of control and communication. In these systems we actually observe the phenomenon of the unique "chemical homeostasis" which is known in chemistry as the Le Chatelier principle.

According to this principle upon the appearance of change in the environment (temperature, pressure, concentration, etc.) certain phenomena occur in a reversible process, which are directed in such a manner that they weaken or reduce to zero the changes in environment which were the cause of the given phenomena and are unfavorable to the reversible process (i.e., to the system). Thus, upon a rise of temperature a reaction which proceeds with an absorption of heat originates in the reversible process, whereas upon a lowering of the ambient temperature, heat is evolved. Upon an increase in pressure (for example, in a mixture of gases) a reaction originates which is accompanied by an increase in the total number of molecules leading to a decrease of pressure in the system. Conversely, a decrease of pressure will produce within the system a reaction which will be accompanied by a decrease in the total number of molecules, i.e., the pressure in the system will increase. It appears that the chemical system "adjusts itself" to the changes in the surrounding medium /See Note7/.

(/Note:7/ As early as 1912, in the Revue de Scientifique an American professor of chemistry, W. D. Bancroft, declared the Le Chatelier principle to be the "universal law" and attempted to trace its action in certain areas beyond the boundaries of chemistry.)

It is evident that in investigating feedback control we encounter not an ordinary physical law of a specific science ("the principle of feedback"), but an extremely general type of regulation, a general objective regularity which applies not only to living organisms and cybernetic machines but to certain other phenomena as well /See Note7/.

(/Note:7/ In the heat of polemics P. Latille (France) declared feedback control to be "the secret of universal organization (order).")

Consequently, there is a reason to assume that in "the foundation of the very structure of the matter" there exists an objective regularity characterizing a general type of regulation which is inherent in all forms of moving matter which exhibit a relatively high level of organization and have a relatively complex and developed structure. This objective regularity under different names (feedback control in radio engineering, deviation control or the Polzunov principle in automation, reverse

afferentation in physiology, Le Chatelier principle in chemistry, feedback control system in cybernetics) was investigated in different sciences at different times.

The forms of moving matter in which this regularity is inherent perceive the changes occurring in the environment and in accordance with these changes independently alter their course of action in the direction advantageous to the further existence and development of these forms. In this sense the feedback principle exhibits a universal character and an over-all scientific significance.

R. Hartley (1928) showed that the transmission of information is a material process ("bodily motion") [See Note 7]. Since the chain of direct and reverse information is a feedback chain and the feedback control process is a constant form or a constant method of control over this information then, consequently, the process of feedback control is as material as the process of the transmission of information.

([Note: 7] R. Hartley, "Transmission of Information." See symposium Teoriya Informatsii i Yeye Prilozheniya (Information Theory and its Application) Moscow, For. Lit. Pub. House, 1959, page 6.)

The higher a specific form of movement of matter the less is its nature explained by the information processes which are inseparable from it and by the feedback control processes. Therefore, neither the physiological nor the social-productive (working) activity of an individual will ever be exhaustively explained merely on the basis of the feedback control [See Note 7]. This does not decrease the significance of the feedback principle as a methodological foundation for studying a large sphere of phenomena of nature, thought, and technology.

([Note: 7] The opposite point of view is upheld by Berkeley, Latille, Yuan, and several other physiologists and cyberneticists of US, Britain and France, who defend the position of mechanization in this problem.)

The philosophical significance of cybernetics consists of the fact that in purging all phenomena and processes of living nature without exception, including the complex and confusing phenomena of instinct, consciousness, and rational adjustment, of mystical, teleological, and idealistic concepts, cybernetics delivers a deadly blow to idealism of all schools and tendencies. For the first time in the history of natural science, cybernetics lays truly scientific foundations for the study and reproduction of living nature by methods and means of exact physical-technical sciences.

The ability of performing independent actions favorable to itself, of self-regulation, self-perfection, and self-organization, contrary to vitalism and teleology contain nothing mystical. It is inherent in all sufficiently highly-organized and complex phenomena and processes of the objective world.

- END -